Parallel Image Compositing API

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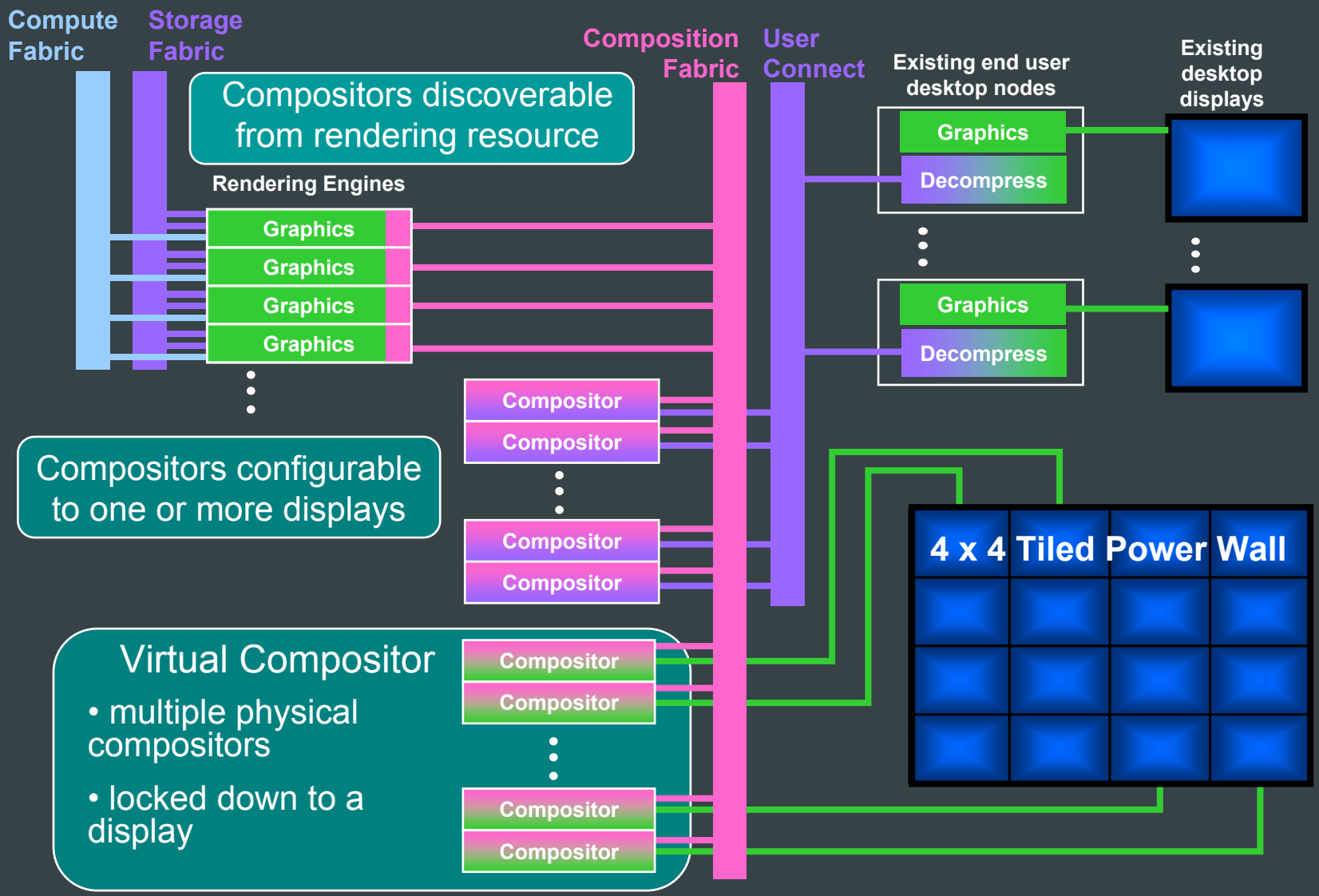
Scalable Visualization Today

- "Standard" commodity clusters
  - Nodes + GPU + Interconnect
  - PowerWalls
  - Remote displays
- Multiple goals
  - Interaction/VR: High frame rates
  - PowerWalls: Large pixel counts
  - Data scaling: High polygon/fill rates
  - Image Quality: Full scene anti-aliasing
- Hardware for "compositing" has focused on:
  - Application transparency
  - Parallel rendering models
- Compositing solutions vary considerably:
  - sv6, Sepia, SGE, Lightning2
  - Many software systems

An Idealized Visualization Environment

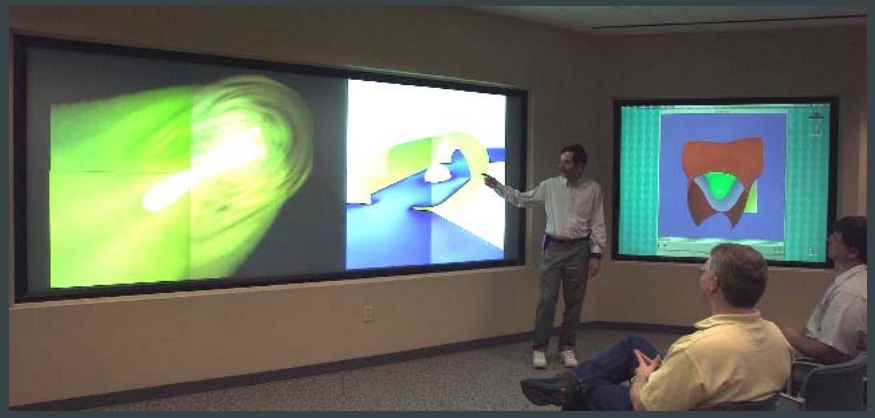


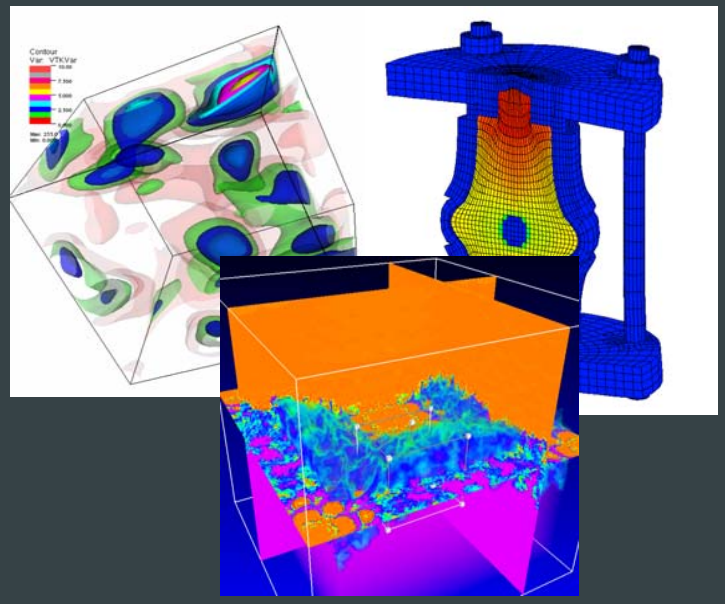
Inhibitors to Compositor Adoption

- Small market
  - Few applications
  - No such thing as a “standard” cluster
  - No common rendering infrastructure for parallel applications
- No common API for compositors
  - Application transparent modes are scalability limited
  - Invasive/custom interfaces to devices for “special features”
- Lack of 2D integration with 3D
- Much of the 3D intensive SW was developed for SMP machines with limited graphics performance
  - Scene graph management
  - Preparing data for the rendering pipeline
- Hardware limitations exist
  - Capabilities of COTS graphics cards
  - Bandwidth available for image fragments

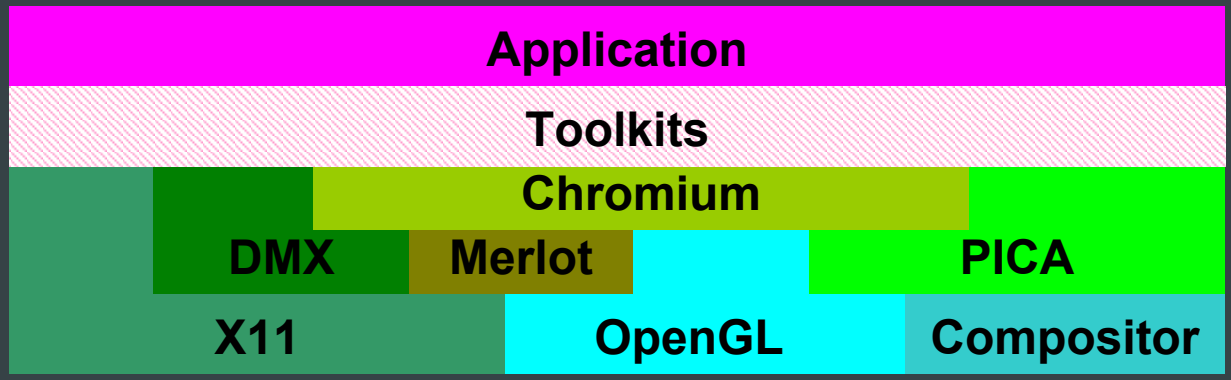
Parallel Image Compositing API (PICA)

- System developers and early adopting app developers
  - Mostly HP, PNNL and LLNL employees
  - Informal API discussions
- Goals
  - Abstraction for distributed image composition
  - Provide an open source API adoptable by ISVs
  - Provides a platform for SW implementations
  - Target major hardware compositors





A Scalable Rendering Software Stack



- Toolkits: “Scene Graphs”, primitive generation
  - OpenRM
  - VTK
  - OpenSG / Open Scene Graph
- Chromium: parallel OpenGL API
- DMX: distributed X11 / windowing
- Merlot: remote image transport interfaces
- PICA: “compositor” abstraction

Underling Assumptions

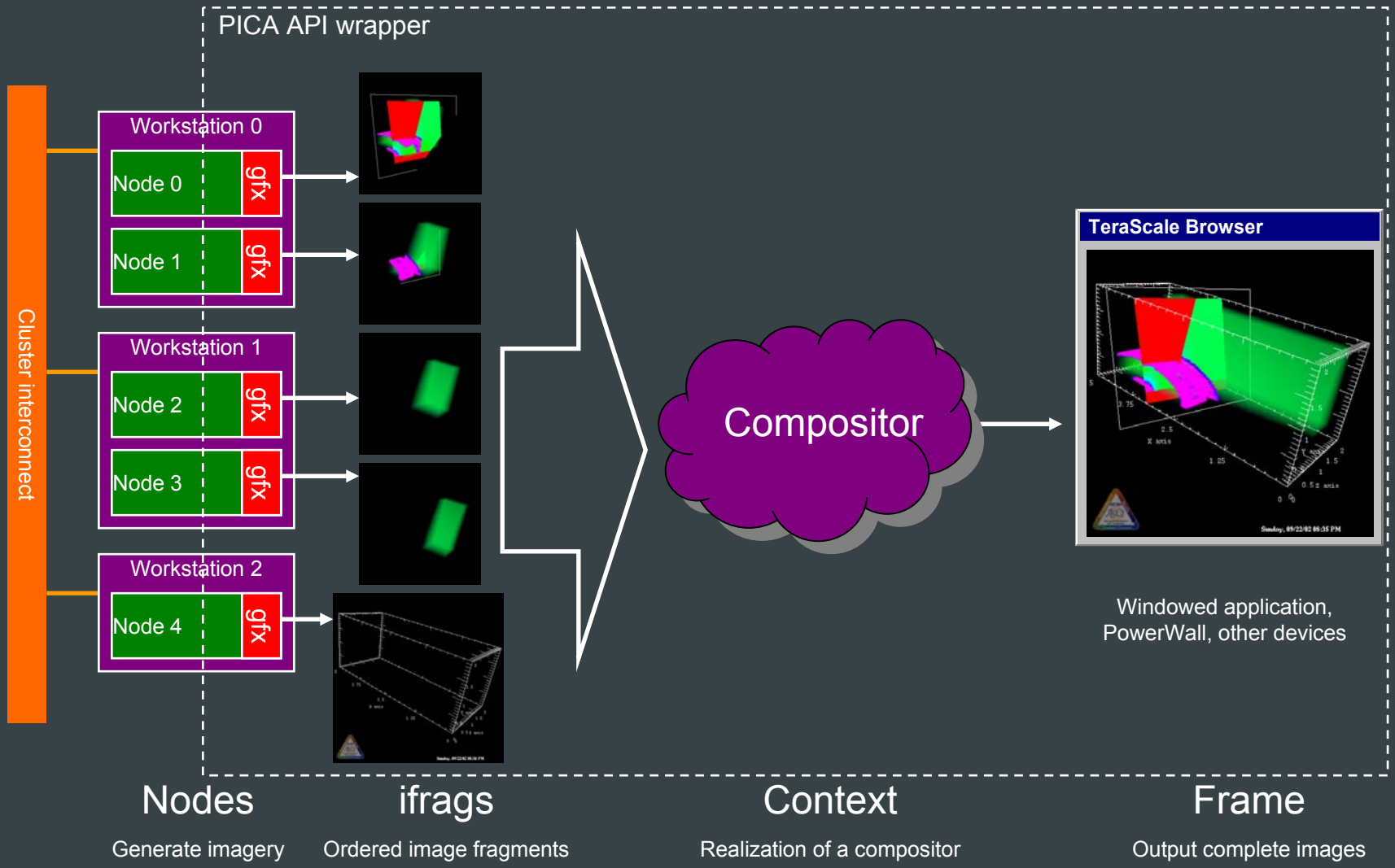
- API targets parallel applications
  - Simple parallel model assumptions
  - Application can pass messages to itself
- API must handle various input sources
  - Region of graphics card memory
  - Software rendering to main memory
  - Must support “windowed” applications

- API must provide a complete compositing abstraction
  - Abstract the concept of composite “ordering”
  - Composting functions covering common usage
- Independent of graphics API
- Must abstract all current compositor forms
  - Multiple compositors available in the same cluster
  - DVI based, network based, software, etc

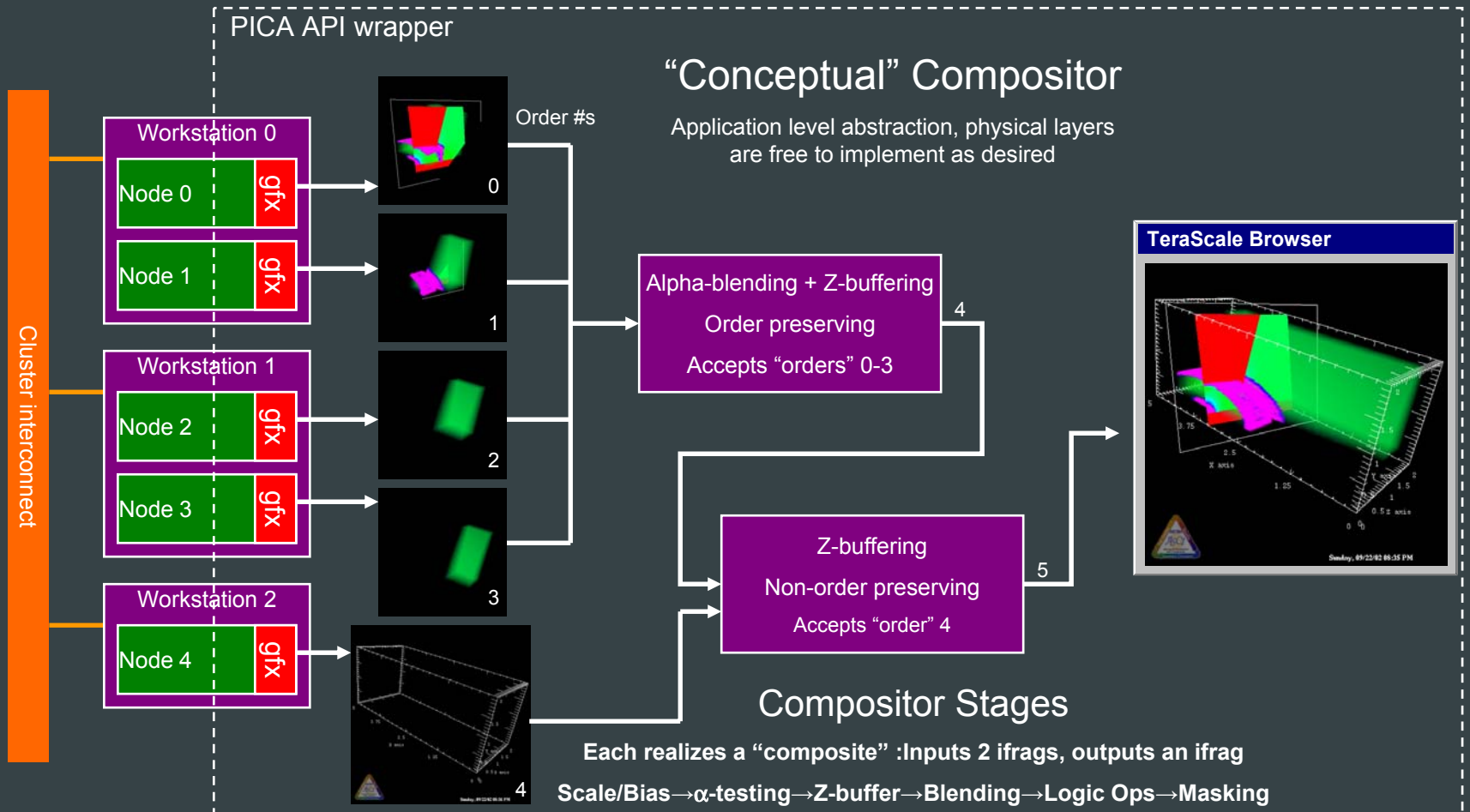
Basic PICA Abstractions

- Application nodes
  - Source of image fragments (ifrag), includes rendering resource
  - Application running on every node
- Application generates a sequence of “Frames”
  - Frames are sequenced by IDs
  - Limited queries Supported via frame IDs
  - Multiple frame “channels” for stereo
- Frames are built from multiple ifrags
  - An ifrag is a rectangle of augmented (e.g. α & depth) pixels
  - Individual nodes can submit multiple ifrags
  - ifrags can be located anywhere in a frame
  - ifrags are tagged with an “order” number within each frame
- “OpenGL”-style compositing pipeline
  - Multiple conceptual “stages” of compositing supported
  - The order of ifrag introduction can be application specified

Compositing Operation in PICA



Compositing Operation in PICA:Details



Basic PICA Operation

initialization

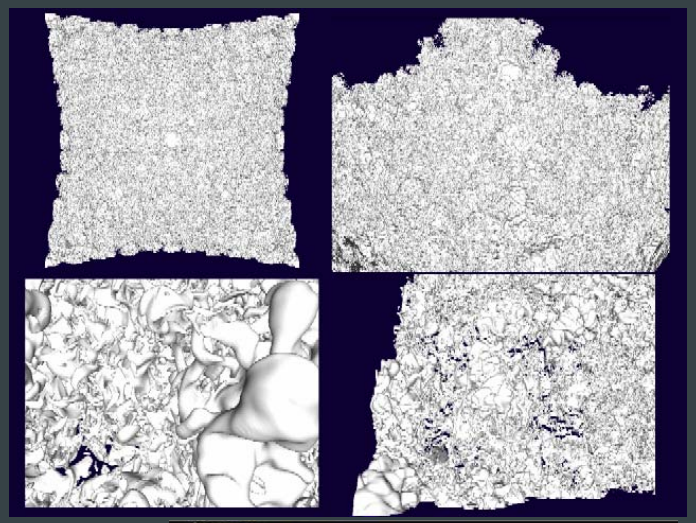
- Compositing “context” negotiated (one node)
  - Includes compositing pipeline definition
  - Hardware is allocated
- Context ID is passed to nodes by application
- Context is “bound” locally (all nodes) to realize the system

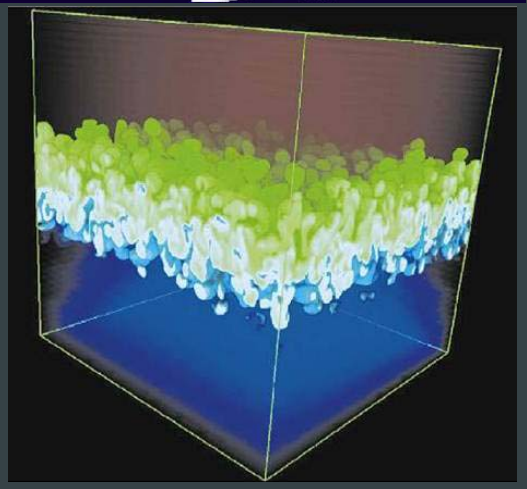
frame based

- Application starts a frame (all nodes)
  - Application renders graphics (generates ifrags)
  - ifrags are passed to local context
- Application ends the frame (all nodes)
  - Composite may occur asynchronously
- Basic query functions allow for application feedback

Technical Details

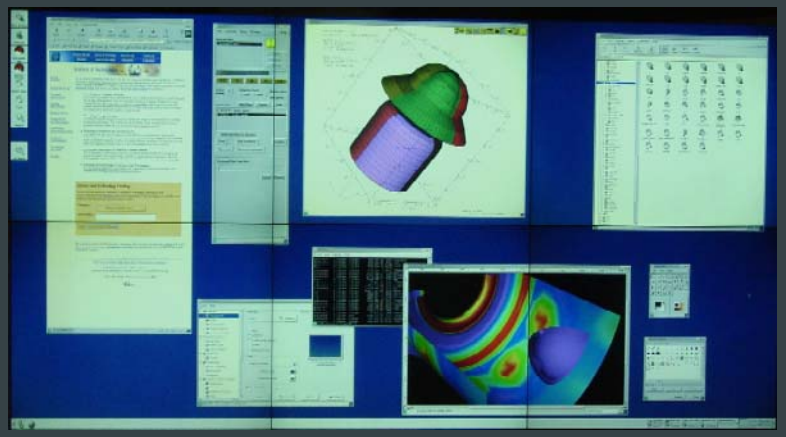
- Compositing happens at the application rate, not at the display rate
- Designed to support 99% of applications
  - Sorted, alpha blending (e.g. volume rendering)
  - Tiling
  - “Overlays” (e.g. annotations, heads-up-displays)
- Advanced composites supported as well
  - Anti-aliasing
  - HW assisted “transparency”
- Provides mechanisms for application “hinting”
  - Performance optimizations (e.g. BSP composite trees)
  - “Specialized” features (e.g. incomplete crossbars)
- Compositing API mostly independent of graphics API
  - Some calls restricted (glXSwapBuffer, glXCreateContext)
  - Special “window manager” specific create context calls





Current Status

- First revision of the specification is complete
  - Written as a communication tool
  - “Human readable” specification next
- Development efforts
  - “C” Stubs written for the API
  - Compiles both apps and compositor
  - Tiered shared library dispatch done
  - Simple software compositor under development
  - Test application under development
- Continued investigations/discussions
  - Mapping to various hardware systems
  - Application transparency issues
  - Parallel system model and security issues



Future Steps

- Work out additional high level technical details
  - Opportunities for performance optimizations
  - Node allocation issues (e.g. multiple graphics pipelines in a node)
  - How to choose a compositor
- Work out next level of details
  - Sample application
  - Partial compositor
- Create sample implementation
- Write drivers to support a HW compositor
- Get API feedback from a wider audience
  - Researchers
  - Application writers
  - HW providers

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